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SAST - Hilsa - 1,21(5), 034, 01

SYNOPSIS OF BIOLOGICAL DATA ON HILSA
HILSA ILISHA (HAMILTON) 1822

Prepared by
S. R. PILLAY
and
H. ROSA, Jr.

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, January 1963

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PREPARATION OF THIS SYNOPSIS

The first draft was prepared by H. Rosa Jr. as a working document for the 7th Session of the Indo-Pacific Fisheries Council (IPFC), Bandung, Indonesia, May 1957.

This revised version has been prepared by the first author, S. R. Pillay.

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1 IDENTITY

1.1 Taxonomy

1.1.1 Definition

Phylum VERTEBRATA
Subphylum Craniata
Superclass Gnathostomata
Series Pisces
Class Teleostomi
Subclass Actinopterygii
Order Clupeiformes
Suborder Clupeoidei
Superfamily Clupeoidae
Family Clupeidae
Subfamily Clupeini
Genus Hilsa Regan 1917
Species Hilsa ilisha (Hamilton) 1822

Three closely related species of the genus Hilsa are found in rivers, estuaries and coastal waters of Asia: Hilsa ilisha, H. toli and H. kanagurta.

Regan (1917) distinguished the three species of hilsa as follows:-

I Parietal ridges expanded and striated
H. kanagurta

II Parietal ridges narrow, covered by smooth skin
1) Caudal lobes as long as head
Scales 45-48/17-20 H. ilisha

2) Caudal lobes longer than head
Scales 40/14-15 H. toli

1.1.2 Description

The following description of Hilsa ilisha is based on Day (1889), Regan (1917) and Misra (1953).

B.5, D.18-20; P.15; V.9; A.18-22; C.19; L.l.45-49; L.tr.17-20; 16-17 pre-ventral and 14-15 post-ventral scutes; parietal ridges narrow, covered by smooth skin; maxillary extending to below middle of eye (young) or beyond; operculum 1/2 to 2/3 as broad as deep; length of head $4\frac{1}{4}$ to $4\frac{1}{2}$; height of body $3\frac{1}{2}$ to 3.3/4 in total length; caudal lobes equal to length of head; eyes before middle of length of head; 1 to $1\frac{1}{2}$ diameters from end of snout and $1\frac{1}{2}$ apart; lower jaw not projecting beyond the upper; ventral fins inserted beneath anterior half of the dorsal; caudal peduncle as deep as long; colour silvery, shot with gold and purple; no spots in the adult, but a row of them along the upper third of the body in the immature.

1.2 Nomenclature

1.2.1 Valid scientific names

The species was first described and figured by Russel (1803) from the foreshore waters of Vizagapatam (- Visakhapatnam) under the name palasah; but because of the faulty nomenclature his work is not recognised by taxonomists. Hamilton (1822) gave the fish its first taxonomic status, describing it under the name Clupanodon ilisha. Regan (1917) created the new genus Hilsa to accommodate the hilsa-like clupeoids of the Indo-Pacific waters and gave clear definitions of Hilsa ilisha and the related species H. toli and H. kanagurta. Regan's nomenclature has remained valid for the species, even though Fowler (1941) and Munro (1955) have assigned it to other genera.

1.2.2 Synonyms

Clupanodon ilisha	Hamilton Buchanan 1822
Clupea palasah	Cuvier 1829
	Günther 1868
Alausa palasah	Valenciennes 1847
	Jerdon 1849
	Day 1865
Alausa ilisha	Cantor 1849
	Bleeker 1852
	Kner 1865
Clupea ilisha	Günther 1868
	Day 1878
	Day 1889
	Lloyd 1907

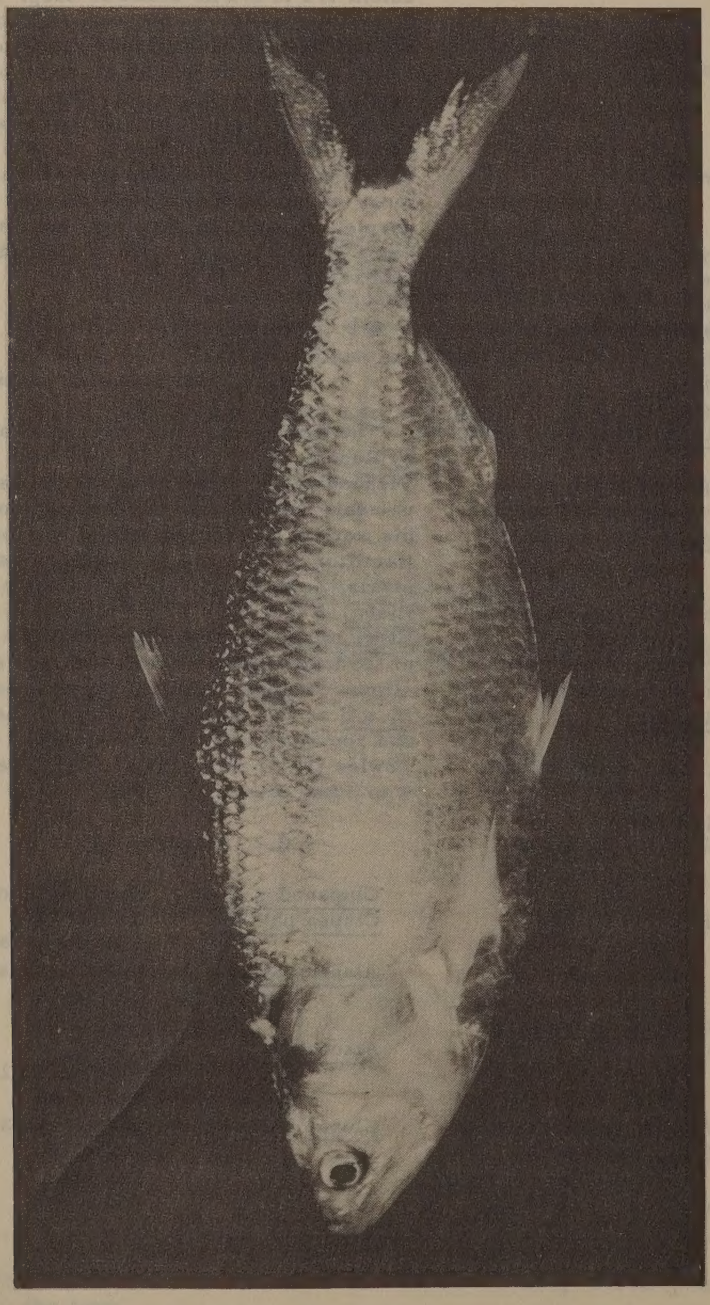

Figure 1. Hilsa ilisha (Hamilton)

Clupea ilisha (contd.)	Tirant 1929
Clupea (Alosa) ilisha	Steindachner 1896
Clupea (Alosa) palasah	Steindachner 1896
Hilsa ilisha	Regan 1917
	Fowler 1934
	Shaw and Shebbere 1937
	Misra 1953
Macrura ilisha	Fowler 1941
Tenualosa ilisha	Munro 1955

1.2.3 Standard common names, vernacular names

(See Table I)

1.3 General variability

1.3.1 Subspecific fragmentation (races, varieties, hybrids)

The probability of there being different races of hilsa was first suggested with some clearness by Jenkins (1940) even though Naidu (1939) and even Day (1873), have referred to it, besides a number of other workers. A detailed study of the problem was conducted by Pillay (1952, 1954, 1957) and Pillay, Pillay and Ghosh, (1963) Preliminary biometric comparison of data relating to body height and length of head of samples from four geographic regions viz. East Pakistan, West Bengal, Uttar Pradesh and Orissa Coast, conducted in 1952, indicated that possibly there are at least three stocks of hilsa in the regions mentioned above, distinguishable by the relative height of body; one stock coextensive from East Pakistan through West Bengal to Orissa coast; the second stock from East Pakistan and Orissa; and the third from Uttar Pradesh.

Biometric comparisons of meristic and nonmeristic characters were made by Pillay (1957) to determine whether the monsoon and winter runs of hilsa in the River Hooghly bear on two different stocks. It was concluded that they constitute a single stock and the only distinguishable difference is in the age composition of fish in the runs. Further detailed studies (IPFC, 1961; Pillay, Pillay and Ghosh, (1963) of samples from different habitats in India have shown that each major river system, the Chilka lake and the Saurashtra coast have their own stocks of hilsa and there is very little, if any intermingling among them. The stocks of Ganga, (there are indications that the hilsa fisheries of Ganga bear on at least two stocks), Padma, Chilka lake, Godavari and Saurashtra coast can be distinguished from the hilsa of the Hooghly by the regression of one or the other body measurement on total length. The height of body, length of head, length, height and thickness of caudal peduncle, thickness of body and diameter of eye were found to be relatively more useful in the identification of the stocks. On the basis of total number of vertebrae, the hilsa of Cauvery and of Saurashtra coast can be distinguished from the rest. The average number of vertebrae for Cauvery hilsa is 44.5 and Saurashtra 45.5, whereas it is less than the former for fish from all other areas. The stocks of Krishna River and Ganga can be distinguished from the others by the average numbers of trunk vertebrae which are 12.1 and 12.48 respectively. Stocks of Chilka, Brahmaputra and Narbada can be distinguished by the average number of caudal vertebrae without haemal spines, which are 11.24, 11.52 and 11.8 respectively. The stock of Padma river can be distinguished from the others by the low average number of vertebrae with duplicate neural spines (20.5).

The results of tagging experiments so far conducted in India have lent support to the above inference regarding the composition of stocks.

The fishermen and fish traders distinguish the hilsa from different river systems in India by their taste, which seems to be largely dependent on the fat content. Comparative studies of fat content of male and female hilsa of comparable size and stage of maturity showed significant differences in the average percentage values as shown in Table II.

Tripathi (1954) has pointed out the possibility of parasitic fauna of different hilsa stocks being different and its probable use in distin-

Table I
Standard common names and vernacular names

Country	Standard common names	Vernacular names
Burma		Nga-tha-lauk
Ceylon	River Shad	
India	Hilsa	
	Indian Shad	1/ Hilsa (Bengali, Hindi) Palasah (Telugu) Oolum, Ulum, Ullum (Tamil) Paliyah, Paluva, Valava (Malayalam) Pussai (Oriya) Palla (Marathi) Paliya (Canarese) Ilish, Ilisha (Bengal, Orissa) Chaksi, Chaksi, Chaski (Narbada River) Ilihi (Assam) Pulla, Pala, Palo (Sindhi) Hilsa, Koira (West Bengal, young up to about 15 cm) Jodi (Young, Chilka Lake)
Irak	Shour	
Iran	Soboor	
Pakistan	Hilsa	Ilish, Palla, Jatka (East Bengal, Young up to about 15 cm)

1/ Bengali, Hindi, Telugu, Tamil, Malayalam, Oriya, Marathi, Canarese and Sindhi are languages spoken in India and Pakistan.

Table II
Fat content of hilsa

Locality	Average percentage
Mahanadi River	19.28
Saurashtra Coast	16.73
Padma River	14.40
Godavari	10.70
Krishna River	8.50
Brahmaputra	7.17
Narbada River	5.40

guishing races (stocks). He mentioned that the parasitic copepod Clavellisa ilisha is present on hilsa from the Hooghly but not on those from Chilka. Similarly, species of Orientophorus are found in different proportions from these two localities.

Preliminary biometric studies conducted in Pakistan seem to indicate that there may be two stocks of hilsa in the East Pakistan rivers whereas there is only one stock in the Indus (West Pakistan).

1.3.2 Genetic data (chromosome number, protein specificity)

No detailed studies on the genetics of hilsa have been made so far. To examine the possibility of using the blood characteristics for differentiation of stocks, Pillay (1954 and 1958 a) conducted studies of the extent of individual variations in the hilsa of the Hooghly. The serological as well as morphological and physiological characteristics observed are summarised in Table III.

Table III
Individual variations noted in the agglutination of erythrocytes

Groups	Human serum (Type)				Sheep serum	Percentage in total number examined
	A	B	AB	O		
Group I	-	-	-	+	+	61.1
Group II	-	+	-	-	+	27.8
Group III	-	-	-	+	-	11.1

Table IV
Morphological and physiological characters

	Mean	S.D.	C.V. (percentage)
Erythrocyte count	3,473,000 per c.mm	549,370	18.82
Erythrocyte cells diameter	6.186 micra	0.8633	13.956
Erythrocyte cells nuclei diameter	3.976 micra	0.7430	18.687
Haemoglobin content	12.66 percent Hellige (0.174 g per 100 c.mm)	1.957	15.670
Coagulation period	13.3 seconds	2.2136	16.644

2 DISTRIBUTION

2.1 Delimitation of total area of distribution and ecological characterization of this area

Hilsa occurs in the foreshore areas, estuaries, brackish-water lakes and freshwater rivers (Fig. 2) of the western division of the Indo-Pacific faunistic region.

Table V
Marine distribution (Tropical Indo-Pacific)

Persian Gulf - Arabian Sea	Bay of Bengal
Persian Gulf Iran, Iraq Arabian Sea West coast of India from Gulf of Cutch along the Saurashtra coast (where it forms a fishery of some magnitude), the foreshore areas near the mouths of Narbada and Ulhas rivers, occasionally found along the Malabar (Kerala) coast	Bay of Bengal Palk Bay, occasionally along the Madras coast; Kakinada coast near the mouth of Godavari (where the fishery is of importance during winter months) occurring in small numbers along the Visakhapatanam coast and caught in appreciable quantities along the Chandipore (Balasore-Orissa) and Midnapore (West Bengal) coasts; also found along the inshore regions near the deltaic area of Burma down to the Mergui Archipelago. Recorded also from the coastal waters of Ceylon and Cochin China

Table VI
Distribution in rivers and brackish-water lakes

Iraq	Iran	West Pakistan	India		East Pakistan
			Western Region	Eastern Region	
Shatt al-Arab	Shatt al-Arab	Indus	Narbada	Cauvery	Brahmaputra
Tigris			Tapti	Krishna	Meghna
Euphrates			Purna	Godavari	Padma
Lake Hammar			Ulhas	(Also the smaller rivers of Korayar	Jumuna and all other deltaic rivers
			Savitri		
			Kali	Pamaniyar, Vellar,	
			Vembanad back-waters	Palar, Pennar, Manneru and Uppeteru)	
				Mahanadi	
				Daya	
				Chilka Lake	
				Hooghly	
				Ganga and its tributaries	
				Padma	
				Brahmaputra	
				Barak	

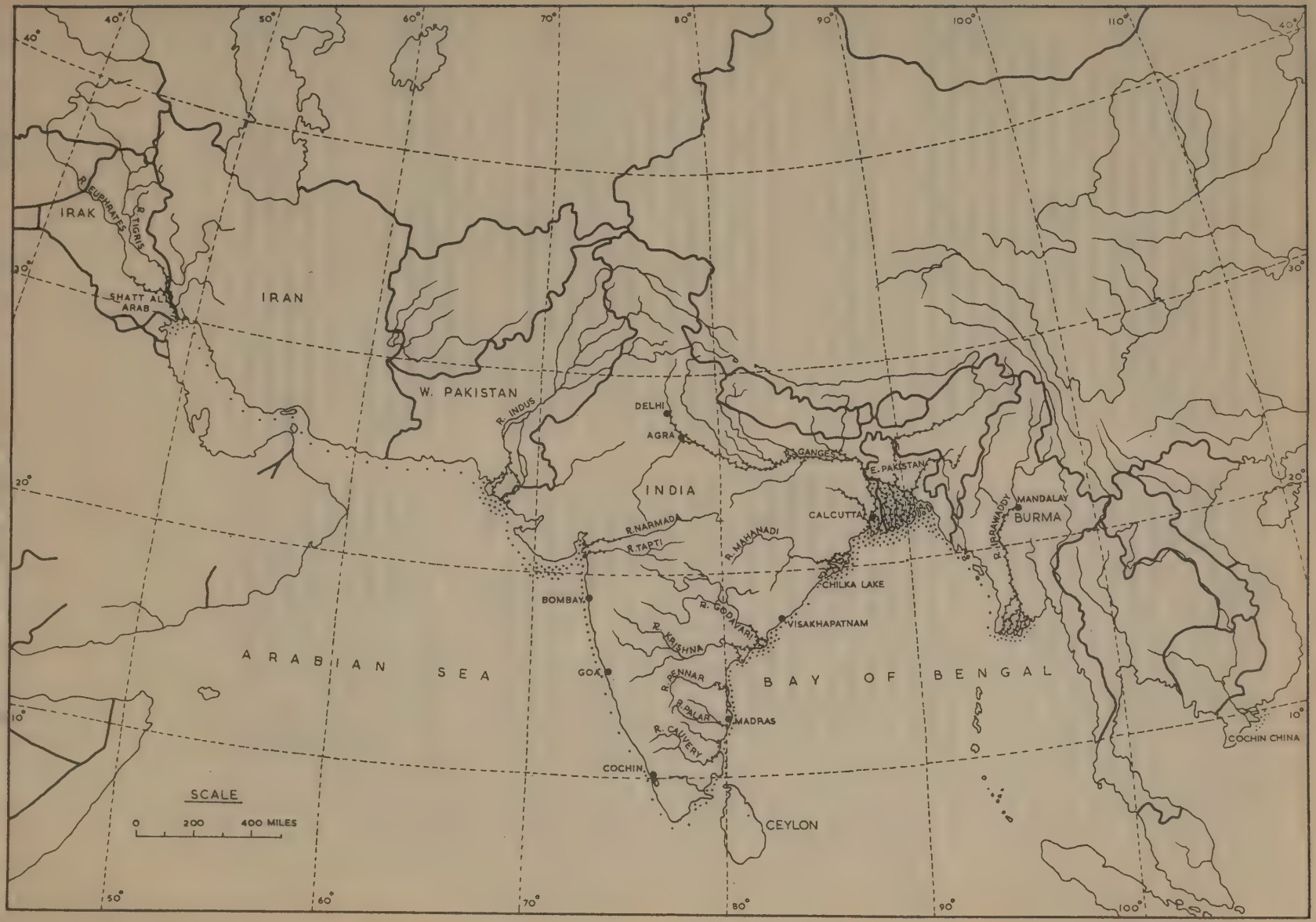

Figure 2. Areas of distribution of hilsa

Oceanographically, the marine distribution of the species coincides with the Indian monsoon region (Arabian Sea, with Persian Gulf and Red Sea, Bay of Bengal, South China Sea with Malayan Archipelago). In general this region is characterised by (1) relatively large continental shelf (2) monsoon winds (3) medium to high precipitation and run-off (4) surface temperature of 20°C - 30°C (5) surface currents changing with the change of monsoons (6) seasonal variation : medium (7) basic organic production : medium to low (8) presence of sub-surface oxygen minimum layer, and (9) relatively low salinity of coastal waters.

The estuarine areas of the rivers and the brackish-water lakes in the area are characterised by strong tidal action, high turbidity and heavy silting. The salinity fluctuates considerably and in areas far inland the water may become entirely fresh during the monsoon months. Thereis a fairly rich growth of plankton except during the rainy season. A greater abundance of zooplankton than phytoplankton (mainly copepods) is usually noticed. The water level in the freshwater areas of rivers falls very appreciably during the dry months, very often exposing large areas of the river bed and converting long stretches into a chain of pools in which the fish fauna takes refuge. During the rainy season, the rivers swell, often suddenly, and result in heavy floods. The turbidity which is usually low, tends to be high during the rainy months and during this period, plankton crop is also comparatively low. In none of the habitats of hilsa does the water temperature decrease very much, even during the winter months. In the river Hooghly, where observations have been made, the usual range of surface water temperature is between about 18°C and 33°C.

2.2 Differential distribution

2.2.1 Areas occupied by eggs, larvae and other junior stages: annual variations in these patterns, and seasonal variations for stages persisting over two or more seasons. Areas occupied by adult stages: seasonal and annual variations of these

All the riverine and estuarine stocks of hilsa appear to breed in the upper reaches, where eggs, larvae and juveniles are found during the spawning seasons. During the southwest monsoon which forms the main breeding season, all the early stages can be found in the spawning grounds. During the succeeding months till about the end of November juveniles and young ones up to about 8 cm length are found in the lower reaches and estuarine areas. Young fish of about 15 cm to 22 cm length occur along the foreshore areas during the winter months. During the breeding season, at the close of winter, from about January to February, all the early stages are found in the upper reaches. Up to about the end of March the young ones are found migrating downstream.

The eggs occur in the sub-surface zones. The juveniles appear to inhabit the surface waters, but later stages move in deeper zones as well.

The normal habitat of the estuarine stocks of hilsa may be considered to be the lower regions of the estuary and the foreshore areas. During the breeding season they ascend the rivers and after spawning, return to the original habitat where they remain till the next breeding season. The riverine stocks, like those of the Ganga and Brahmaputra, appear to remain in the freshwater areas throughout the year, but there is a greater concentration in the lower reaches during the period between breeding seasons. During the breeding season the maturing fish migrate upstream and after spawning, return to the lower reaches.

A marked zonation in the occurrence of the adults migrating upstream for spawning has been observed in the Hooghly river (Pillay, 1958) during the winter season, when the males move in the surface zone and the females in deeper areas.

In the sea, hilsa occurs mostly in the areas very near the coast except on the Saurashtra coast, where they are found 13 km to 16 km off the coast in depths up to about 20 fathoms, and occasionally on the Bombay Coast 16 km to 24 km

off-shore. According to Mojumdar (1939 a) hilsa move on the surface in the sea, whereas in the river they move at a depth sometimes of 30 to 40 cubits (about 13.7 m to 18. 3 m) though on a cool or drizzling day they may come within 4 to 5 cubits (1. 8 m to 2. 2 m) from the surface. In very shallow rivers they have been observed to move in much lesser depths also.

The upstream migration during the main breeding season appears to depend largely on the commencement of the southwest monsoon and consequent flooding of all the rivers of Burma, Pakistan and India. The variations in the intensity of monsoon during the breeding season appear to cause considerable fluctuations in the abundance of the fish and catches in different places. According to Day (1873) the breeding migration in the Indus and Upper Irrawady, takes place when the rivers are flooded by melting snow, not by monsoons. Jones (1959) has indicated that the up-river migration of hilsa in the latter part of winter in the Hooghly is governed by the sudden increase in temperature. According to Talbot (1959) the hilsa run in the Indus begins in January and is over by the end of September. Investigations are necessary to decide whether this constitutes a single run or two runs as observed in some of the other major rivers.

2.3 Behaviouristic and ecological determinants of the general limits of distribution and of the variations of these limits and of differential distribution

As already stated, for most stocks of hilsa the lower regions of the estuaries and the adjacent foreshore areas form the permanent habitat. They ascend the rivers for spawning, but the extent of migration varies considerably. In the Irrawady, hilsa is known to ascend to Upper Burma in the neighbourhood of Mandalay, a distance of about 724. 2 km from the sea. In East Pakistan, they ascend the whole span of the Gangetic Delta system. The range of migration in the Brahamaputra (India) is up to Tezpur, a distance of about 306 km from the East Pakistan border. The stock of hilsa in the Ganga migrates as far up as Agra and Delhi, covering a distance of about 1, 287 km. In West Bengal, hilsa ascends the river Hooghly for about 298 km but it does not enter the adjacent river of Mallah probably because of the lack of influx of fresh water into it. In the rivers Mahanadi, Godavari, Krishna and Cauvery the extent of migration has been greatly restricted by the construction of anicuts and dams. In the Mahanadi the fish have been observed to migrate up to Naraj anicut which is about 97 km from the river mouth, but during exceptionally heavy floods it is reported to ascend as far as Sambalpur, about 402 km from the sea. In the Godavari, Krishna and Cauvery, the ranges of migration are generally up to the lowermost anicuts which are located at distances of 97 km, 97 km and 56 km respectively from the river mouths; but during high floods the fish are able to ascend further. The hilsa of Chilka lake ascend the river Daya probably for a short distance for breeding. The migration of the species in the Narbada is restricted to about 151 km and this is considered to be due to the swift current (about 3 m per second) and the turbulence in the upper reaches. Only the older hilsa which are apparently stronger, seem to be able to negotiate the rapids and reach the upper limit of distribution of the species in the river. In all the big rivers, the fish also ascend the major tributaries. In the smaller rivers on the west coast they migrate only to very short distances from the river mouths. It is reported that hilsa is not known to ascend higher than about 8 km in the Purna river. Similarly, in the Ulhas river, it is known to ascend only about 40 km. In the Indus (West Pakistan) the migration is up to the Ghulam Mohammad Barrage which is a distance of about 161 km from the sea. The limits of migration in the rivers Euphrates and Tigris in Iraq are not fully known, but in the Euphrates it appears to be up to Yaou and Meshkhau (Van den Eelaart, 1954).

It has been observed that during years of great abundance of the fish, the usual limits of distribution may be extended. Such instances have been recorded in the Brahmaputra where hilsa catches were made even in areas above Tezpur during 1955 (Pillay and Ghosh, 1958) and in the small tributaries of the Ganga, through which the fish ascended into lake Mahasra tal during 1954 (Banerji, 1955). Even though there is as yet no definite proof, there is a belief that the silting of rivers is responsible for the reduction in the number of hilsa ascending rivers

and brackish-water lakes. Chacko and Dixithulu (1951) have observed that when the water level in the Godavari was low due to failure of floods and silting during the season of 1959, the fish migrated along the shore and provided a lucrative fishery on the Kakinada coast.

3 BIONOMICS AND LIFE HISTORY

3.1 Reproduction

3.1.1 Sexuality (hermaphroditism, heterosexuality, intersexuality)

The species is heterosexual. An instance of hermaphroditism has been reported by Chacko and Ganapati (1949) who found a specimen of the fish from the river Godavari with the anterior one-third of both the lobes of the gonad having the structure of testes and the posterior two-thirds, the structure of ovary. The females attain larger size than the males, the former having a higher growth rate. There are no accessory reproductive organs or other external morphological features for the identification of the sexes.

3.1.2 Maturity (age and size)

The riverine stocks of hilsa studied in India appear to attain maturity when they are about one to one and a half years old. Some workers have expressed the view that males mature earlier than females, but critical evidence is not yet available to prove this.

Chacko and Ganapati (1949) mentioned that in the river Godavari the males probably attain maturity when they are of the 30 cm age group and the females 35.6 cm age group. Chacko and Krishnamurthy (1950) concluded on the basis of scale markings (identified by them as spawning rings) on hilsa from the Godavari that 28 cm long males had spawned once and 38.2 cm long females twice. The smallest mature male hilsa, observed in the Godavari by Pillay and Rao (1962) was 25.6 cm and the smallest mature female 37.0 cm long. In the case of hilsa of the Hooghly the minimum size at maturity of females was observed to be between 19 cm and 20 cm and the males 16 cm and 17 cm (Pillay 1958). Karamchandani (1961) has reported that the Narbada hilsa (female) attains maturity at the greater length of 26.5 cm.

3.1.3 Mating (monogamous, polygamous promiscuous)

Direct observation of the mating behaviour has not been made, but the species appears to be polygamous.

3.1.4 Fertilization (internal, external)

External.

3.1.5 Fecundity

Relation of gonad size and egg number to body size and to age

The relationship between fecundity and body weight of hilsa of the Hooghly is linear, the equation being $F = 1.2662 + 0.00801\ W$ and the relationship between fecundity and length is exponential, the equation being $F = 0.9550\ e^{0.0539L}$. (F = fecundity, W = weight and L = length) (Pillay, 1958). The fecundity of hilsa in the river Hooghly has been found to range from 250,000, to 1,600,000 depending on the size of fish. Chacko and Ganapati (1949) observed that a mature female weighing 910 g from the Godavari, contained 1,282,100 ova. Pillay and Rao (1962) found the fecundity of the Godavari hilsa to be higher than that of the Hooghly hilsa, the relationship of fecundity to length of fish being $F = 1.22132\ e^{0.3946\ L}$ where F is fecundity in thousands, L is total length in cm, and e the base of the Naperian logarithm. Kulkarni (1950) estimated about 1,864,000 ova from an ovary of a hilsa weighing 2.1 kg from the Narbada. The fecundity of Indus hilsa is reported to range from 7 lakhs to 29 lakhs (IPFC, 1961).

3.1.6 Spawning

- Spawning seasons (beginning, end, peak)

The main breeding season is during the southwest monsoons, the commencement and duration of which vary to some extent in different parts of the regions of distribution of the species. A shorter breeding season extending from January to February or March has been observed in some of the major rivers. Even in other areas where an extended spawning season from June-July to about February is reported, it is quite probable that there are really two distinct breeding seasons with an interval of at least a month which has escaped observation on account of the catches of spent or young fish during the interval. Kulkarni (1950) and Karamchandani (1961) have observed that there is a lunar periodicity in the spawning of hilsa in the Narbada. Peak collections of hilsa eggs were made from the river by the latter worker during spring tides. As the fishery in most rivers is dependent on their migration for breeding, the duration of the fishing season and the peak periods

of fishing given in section 5.3 would also give some rough idea of the duration and peak periods of spawning respectively.

On the basis of information on the occurrence of young hilsa in the Pulta water works, Hora and Nair (1940) and Hora (1941) inferred that the fish breeds in the river Hooghly throughout the year, the peak period being about July-August and a second low peak in May. Based on maturation studies, Pillay (1958) has described the breeding season in the Hooghly as from the beginning of the southwest monsoon to November and again from January to February or March. Motwani, Jhingran and Karamchandani (1957) have reported that the breeding of hilsa in the Ganga would appear to commence with the onset of the monsoon season in July, with peak breeding from September to December. Nair (1958) studied the morphological and histological features of the gonads of hilsa from the river Ganga at Benaras and found that spermatogenesis and oogenesis start by the end of January, reaching a peak in March and again in June, attaining a peak by August. He observed however that during the first period of peak gonadial activity the ova undergo atresia and resorption, even though the spermatozoa are shed. According to him it is only during the later period that actual spawning takes place. In the Narbada, Karamchandani (1961) found that the main spawning season commences in June-July and continues up to September, the peak being in August when the river was flooded to the maximum. Pillay (1962) observed that hilsa of the Saurashtra coast breed during the pre-monsoon months of April and May. The spawning season of the Godavari hilsa lasts from about August to November (Pillay and Rao, 1962).

As previously mentioned the upriver migration of the fish during the main breeding season and consequently the breeding season itself, is largely dependent on the flooding of the rivers.

- Number of spawnings per year, frequency

On the basis of ova maturation studies, Pillay (1958) has concluded that the fish breeds intermittently during the breeding season. The ova that are likely to be spawned during the season have a size range of 252 to 882 micra and no distinct size groups could be observed among them, which indicates that spawning takes place several times during the season. Chacko and Krishnamurthy (1950) have presumed that the hilsa of the Godavari breeds eight times in its life on the basis of the maximum number of spawning rings recognised by them on the scale (eight for females and seven for males).

- Spawning time of day

On the basis of observations on development stages collected from the spawning grounds Jones and Menon (1951) have expressed the view that the spawning time of hilsa is towards the afternoon and evening. Similar studies by Karamchandani (1961) in the Narbada indicate that spawning also takes place in the early hours of the morning.

- Induction of spawning, artificial fertilization

Very little is known about the factors that induce spawning. Southwell (1914) seems to suggest that the changes involved in the transition from the sea to fresh water induce spawning. Nair (1958) studied the variation in water temperature of the Ganga near Banaras and the gonadial activity throughout the year and expressed the opinion that very high temperatures have perhaps an inhibitory effect on maturation of the ovary. The floods during the rainy season, which make the water turbid and the current flow faster, were considered by him to be most favourable for spawning.

With a view to artificially propagating the species for restocking the rivers, experiments were conducted in Madras and Bengal States in India and a hatchery was established at Bobbarlanka on the Godavari. Artificial fertilization and hatching of eggs are reported to have been done successfully both in the Bobbarlanka hatchery and in Bengal, but rearing the hatchlings to a size suitable for stockings the rivers was found to be extremely difficult and so the attempts were given up. Kulkarni (1950) conducted artificial fertilization of hilsa eggs for studying the developmental stages and was able to rear the larvae for three days. Karamchandani (1961) reared hatchlings up to 14 days which were obtained from eggs hatched in the laboratory.

3.1.7 Spawning grounds

Southwell and Prashad (1925) expressed the opinion that there are no fixed breeding grounds for the fish in the generally accepted sense of the term and that they probably breed during the rains, when conditions such as weather, temperature and other undetermined factors are suitable.

The first positive evidence of the location of spawning grounds was discovered by Hora (1938) when he identified the young of the species from the Pulta water works tanks, into which they would have gained access only in the form of eggs or early larvae, because of the very narrow suction space in the centrifugal pumps at the intakes. He inferred that the stretch of Hooghly river near Pulta water works formed one of the spawning grounds of the fish. This was confirmed by further observations made by Hora and Nair (1940) and Jones and Menon (1951). Pillay (1958) on the basis of ova studies inferred that the lower limits of the spawning grounds of hilsa in the river is Bagh Bazar in Calcutta. There is evidence to show that they breed upstream, up to Medgachi, a distance of about 251 km from the sea. The hilsa of Chilka lake spawns in the lower reaches of the Daya river (Jones and Sujansinghani, 1951). In the South Indian rivers of Godavari, Krishna and Cauvery, the spawning grounds are below the lower-most anicuts, but when there are high floods and the shutters are opened the fish migrate and spawn in the upstream region also. Chacko and Ganapati (1949) have mentioned that mature hilsa congregate close to the anicut and wait for the water level to rise above that of the anicut to move upstream for spawning and several fish spawn below the anicut while they wait to go upstream. Pillay and Rao (1962) found that the breeding grounds of hilsa in the Godavari extend to nearly 35 to 40 miles downstream of the Dowlaiswaram anicut into the Gautami and Vainateya branches of the river.

Kulkarni (1950 and 1954) located hilsa spawning grounds at the lower reaches of Narbada river in the region of about 72 to 88 km from the river mouth. Further observations by Karamchandani (1961) have shown that the fish breeds also in the freshwater regions of the river, below the upper-most limit of its migration (about 161 km from the sea) in a stretch of about 29 to 32 km. From observations on the size composition of catches he has concluded that only older hilsa (males 31.5 cm to 48.5 cm and females 41.5 cm to 55.5 cm) migrate to the freshwater zones for breeding and that the younger fish breed in the tidal zone. Southwell (1914) has also suggested such a possibility in the rivers of eastern India. Motwani, Jhingran and Karamchandani (1957) have described the spawning grounds of hilsa in the Ganga as the stretch of the river between Patna (Bihar) and Allahabad (Uttar Pradesh). The presence of larvae in the neighbourhood of Lalgola (in the river Padma) indicates the probability of the fish spawning in that area also. The presence of spent hilsa in the seas off the Saurashtra coast where there are no big rivers up which hilsa ascend, has indicated the possibility of the stock of the area breeding in the sea itself. (Pillay, 1962) In the Indus in West Pakistan the spawning grounds have been restricted by the construction of the Ghulam Mohamed Barrage, below which the fish now spawn.

Van den Eelaart (1954) working in Iraq did not have the opportunity to determine accurately the spawning grounds of the species, but indicated that the main grounds are probably in the Euphrates, somewhere between Shinafiya and Samawa and in the Tigris between Amara and Qalat Saleh.

3.1.8 Egg: structure, size, hatching type, parasites and predators

The diameter of the fully ripe ovarian egg has been recorded as 0.70 mm to 0.75 mm by Jones and Menon (1951) and 0.89 mm by Pillay (1958). The egg, when laid in water and fertilised, swells to 2.1 mm to 2.3 mm in diameter and is demersal in still water; but its density being very close to that of water, it is easily buoyed up and drifted by slight currents (Kulkarni 1950). The egg membrane is elastic and the vitelline space is wide. The yolk is segmented and has numerous oil globules of varying sizes, which coalesce later to form a large and conspicuous globule (Jones and Menon, 1951). Kulkarni (1950) and Motwani, Jhingran and Karamchandani (1957) stated that the hilsa egg has double-layered membrane, but Jones and Menon (1951) observed that the double layering takes place as a result of post-mortal changes. There is no information available on the parasites and predators of hilsa eggs in nature. During experiments in artificial fertilization in Bengal, it was observed that mor-

tality may occur due to bacterial and fungal (Saprolegnia ferax) infection (Southwell and Prashad, 1918 a).

3.2 Larval history

3.2.1 Account of embryonic and juvenile life (prelarva, larva, postlarva, juvenile)

Kulkarni (1950) has given the following account of the development of artificially fertilised eggs of hilsa. (Table VII)

The temperature of the water in which the eggs were hatched was between 28°C and 28.5°C. The hatching time varied from 18 hours to 26 hours depending on the temperature, oxygenation of the water, etc. Observations by Jones and Menon (1951) on developing eggs collected from the Hooghly showed a longer incubation period which might have been due to the lower temperature of the water (23°C) in which they were reared. They found considerable retarding of growth with drop in temperature of water. Motwani, Jhingran and Karamchandani (1957) observed the incubation time to be 24 to 28 hours.

The newly hatched larva is 3.1 mm according to Kulkarni (1950) and 2.3 mm according to Jones and Menon (1951). Motwani, Jhingran and Karamchandani (1957) found the length of newly hatched larvae to be 2.5 mm to 2.55 mm and Karamchandani (1961) found it varying between 2.4 mm and 3.0 mm.

The larval development of hilsa is described in Table VIII.

Kulkarni (1950) has also described the larval development up to the three days old larva; but the lengths of the first, second and third day larvae given by him as 3.1 mm, 3.9 mm and 4.2 mm respectively, correspond to those of the second, third and fourth day larvae described by Jones and Menon (1951). Kulkarni (1950) has noted the following additional developmental features in the larvae studied by him;

3.7 mm larvae: A tubular pulsating heart is visible between the head and the yolk-sac, about 42 muscle segments are visible, the anus appears at about the 38th segment.

4.2 mm larvae: Eyes pigmented and very prominent, red blood corpuscles seen coursing through the tubular pulsating heart, a distinct mouth is apparent, the larvae still swim upside down, but rest on the sides.

According to Karamchandani (1961) the larval stage of 6.5 mm length described by Jones and Menon (1951) corresponds to the tenth day larvae of 5.8 mm length studied by him. While Jones and Menon (1951) have stated that larvae attain 8.0 mm length in about a week after hatching, Karamchandani (1961) found two weeks old larvae to measure only 5.8 mm to 6.2 mm in length.

- Feeding

Jones and Menon (1951) have observed that the food of hilsa larvae consisted mainly of diatoms and copepods. Hora and Nair (1938 and 1940) found that young hilsa between 20 mm and 40 mm in length feed mostly on diatoms and sparingly on copepods, daphnia and ostracods. Older ones up to 100 mm in length were found to feed on smaller crustaceans mentioned above and also on insects such as corixid bugs, chironomid larvae, etc. and polyzoa. Still older specimens up to 150 mm in length included small shrimps in their diet. On account of the presence of sand grains in the stomach they inferred that the young hilsa feed at the bottom. Hora and Nair (1940 a) made a special study of the food of young hilsa in East Pakistan rivers and found that they feed on filamentous algae, diatoms and copepods. During February and March algae constituted the bulk of the food eaten, while during norwesters (March-April) diatoms formed the main item.

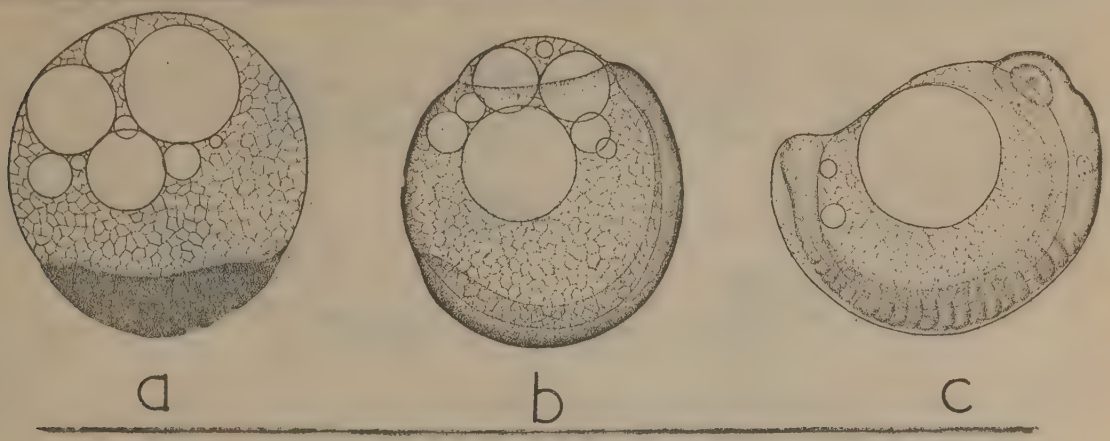

Figure 3. Embryonic stages of Hilsa ilisha (X80) (After Jones & Menon, 1951)

(a) Advanced blastodermal cap just before the formation of the segmentation cavity.
(b) Embryo an hour before the closing of blastophore.
(c) Embryo 15 hours after the earliest stage observed.

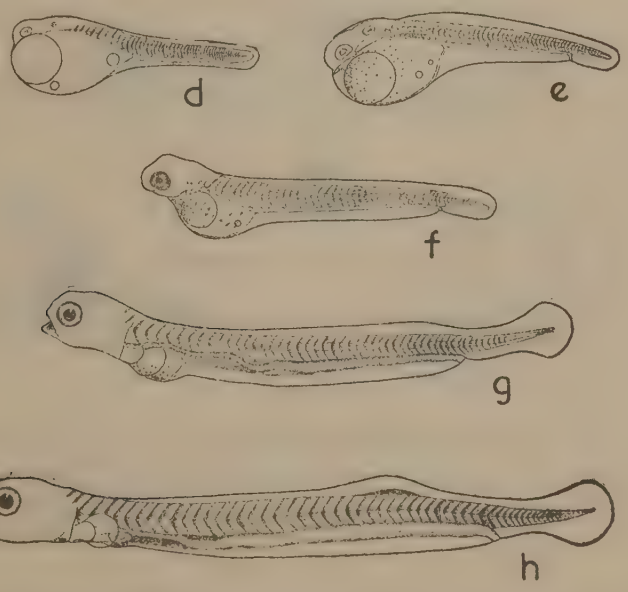

Figure 4. Larval stages of Hilsa ilisha (X18) (After Jones & Menon, 1951)

(d) Newly hatched larva
(e) 12 hour old larva
(f) 60 hour old larva
(g) 5.6 mm stage
(h) 6.5 mm stage

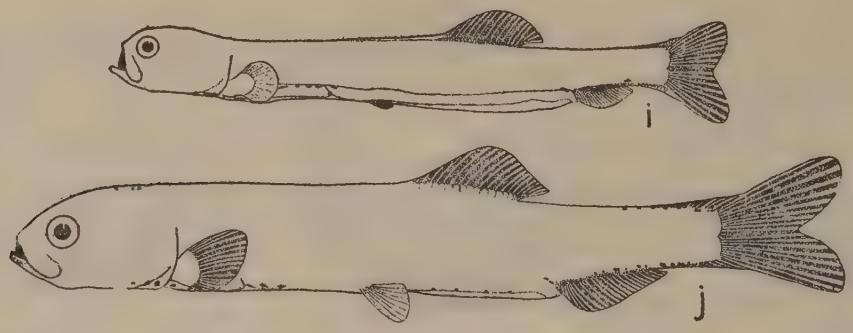

Figure 5. Larval stages of Hilsa ilisha (X8) (After Jones & Menon, 1951)

(i) 14 mm stage
(j) 18 mm stage

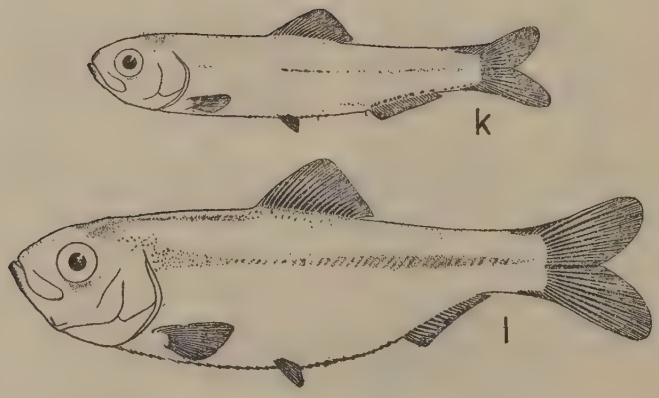

Figure 6. Post-larval stages of Hilsa ilisha (X4) (After Jones & Menon, 1951)

(k) 20 mm stage
(l) 30 mm stage

Table VII
Development of artificially fertilised eggs
(Kulkarni 1950)

Time in hours after fertilisation	Developmental features
Within 1/2 hour	Blasto-disc is formed
Within 4.1/2 hours	Segmentation of blasto-disc forming a cap of cells covering half of the yolk
After 8.1/2 hours	Embryonic shield visible
After 12 hours	Embryo is distinct, with head and a free tail. A few myotomes visible but the optic vesicle is not discernible
After 15 hours	Contrations of the embryo begin
After 18 hours	Hatching takes place

Table VIII
Larval development of hilsa
(Based mainly on Jones and Menon 1951)

	Development
Days	
1	2.3 mm long, sinks to the bottom, large oil globule close to the head, auditory organs very distinct, position of anus indicated near the 40th myotome
2	3 mm concentration of pigment spots in the region of oil globule, eyes begin to turn dark
3	3.75 mm head freed from yolk sac, rudiments of pectoral fins present, alimentary canal appears as a fine tube without visible anal opening, indication of formation of mouth, hind margin of operculum faintly differentiated, rudiments of gills visible
4	The larva is slightly longer, with the caudal end broader and rounded, the mouth, gills and operculum better developed, yolk appreciably reduced and the eyes darker
5	5.6 mm yolk partially consumed, distinctly formed mouth anterior in position, alimentary canal clearly differentiated
Stages (mm)	
6-7	(6.5 mm) Yolk much reduced, larva begins to feed on minute copepods and other organisms, first indication of dorsal fins, fin-rays being formed
8	Yolk completely absorbed, mouth terminal and lower jaw slightly longer than the upper, thin transparent maxilla is visible, eyes large and black, liver extends up to the eleventh myotome, anal opening near the fortyth myotome, the larva feeds on diatoms and copepods, tip of vertebral column bent upwards, air bladder between thirteenth and eighteenth myotomes

Table VIII (contd)

Stages (mm)	Development
10	In general shape this stage is more or less similar to the previous one. Fin rays indicated on dorsal, anal and caudal fins
12	The gill rakers can be seen through the operculum, hypurals and 19 caudal fin-rays distinctly seen
14	Vertebral spines formed in the posterior half of the body, indication of ventral fins, dorsal fin with 18 rays, 18 rays in the anal fin, caudal fin typically homocercal, anus shifted forward to 34th-35th myotome
16	The body of the larva is uniformly wide up to the anal region, jaws are well developed with the lower jaw bones having fine conical projections on their anterior edge, the dorsal fin with 19 rays, the anal fin with 19-20 rays, the pelvics with 9 rays and on the pectorals indication of 8-10 rays. Alimentary canal shows distinct fold behind liver, the anus shifted to 32nd myotome
18	The intestine is coiled on itself, in the pectorals 10 rays are distinctly seen, the pelvic girdle is in the course of formation, the anus situated near the 30th myotome
20	The larva has a shape characteristic of the clupeoids. The full complement of rays of all the fins including the pectoral and the anal is present, the vertebrae are all well demarcated, there are 5 to 7 scutes in front of the pelvic fin, scales begin to develop and are distinctly visible when the larva is about 21 mm long

Table VIII (contd)

Stages (mm)	Development
24	27 scutes present, origin of dorsal fin in advance of the anal
26	Shape roughly of the adult, 30 scutes on the ventral edge of the abdomen, dorsal fin commences about the 9th segment, lateral band of pigment spots on body
30	All the 31 scutes that are found in the adult fish are fully formed, the lateral band is distinct, the dorsal fin commences about the 8th segment and the anus at the 30th
41	Concentrations of pigment appear in the form of dark blotches along the lateral band which are the characteristic markings of young hilsa

- Rates of: development and survival

The rate of development of hilsa embryos is to some extent influenced by temperature conditions. At an average temperature of 23°C Jones and Menon (1951) found that hatching took place in about 23 to 26 hours. Kulkarni (1950) found that hatching took place in 18 to 26 hours in water of about 28.5°C. Motwani, Jhingran and Karamchandani (1957) have given the incubation period as about 24 to 28 hours, but they have not indicated its relation to the water temperature. According to Hora (1938) the brood of July-August may attain a length of 140 mm-150 mm by the third week of November. Hora and Nair (1940) record a growth of 35 mm a month during November, while in the summer months the rate is as high as 50 mm. Sujansinshani (1957) made a study of the growth of juvenile hilsa from the river Hooghly and concluded that in the first month after hatching they grow to about 28 mm and in the subsequent two to three months from 15 mm to 20 mm per month. Thereafter the growth rate falls to about 10 mm per month. Jones and Menon (1951) found that in the Chilka lake the July-August brood grows to about 110 mm to 133 mm by the first week of December.

No information is available at present on the rate of survival of the early stages of the fish, but it has been observed that the operation of small-meshed nets in the period immediately succeeding the breeding season in the river Hooghly results in large-scale destruction of young fish.

- Parasites and predators

The occurrence of parasites in the early stages of the fish has not been studied, but no large-scale mortality has been observed to have been caused by parasitic infection. No specific information is available on the predators of the embryonic or larval stages, but it would appear that the predators of the adults feed on the early stages as well.

3.3 Adult history

3.3.1 Longevity

On account of the difficulties experienced in the determination of the age of the species, it has not yet been possible to estimate correctly its longevity. Based on preliminary study of the scales, Prashad, Hora and Nair (1940) tentatively estimated it to be five to seven years. Pillay (1958) has been able to recognise up to 5 year age groups in the commercial catches in the Hooghly and Pillay and Rao (1962) recognised + 6 year groups in the Godavari.

3.3.2 Hardiness

It was believed that hilsa, especially the maturing ones, were very delicate, and that mere capture by a net and handling, was sufficient to kill them (Southwell and Prashad, 1918 a). But later investigations have shown that it is possible to catch them alive and mark them successfully with nylon streamer tags (Pillay 1959; Pillay, Rao and Mathur MS). Pillay (1958) also found that young hilsa could be reared under artificial conditions.

3.3.3 Competitors

Hilsa being predominantly a plankton feeder, it would appear that other plankton feeding fishes found in its habitat, such as a number of species of clupeoids, compete with the species for food.

3.3.4 Predators

Southwell and Prashad (1918) have reported that the shark, Carcharinus gangeticus Müll and Henle, the Gangetic porpoise, Platanista gangetica Lebeck, the otter, Lutra vulgaris Erxl. and the mugger, Crocodilus porosus Schn. are the main predators of hilsa in the Ganges.

3.3.5 Parasites and diseases

The following parasites have been recorded from hilsa but none of them has been observed to cause any recognisable diseases or mortality in the species (Southwell and Prashad, 1918,

1923; Srivastava, 1935, 1935 a, 1935 b, 1941; Chakravorty, 1939, 1943 and Tripathi, 1952, 1959, 1962).

Protozoa - Myxosporidia:

Ceratomyxa hilsae Charkravarty (from gall bladder)
Zschookkella ilishae Chakravarty (from gall bladder)

Trematoda - Digena:

Lecithaster indicus Srivastava (from stomach)
L. extralobatus Srivastava (from stomach)
Clupenurus piscicola Srivastava (from intestines)
Sterrhurus sihami Srivastava (from stomach)
Aphanurus stossichi Monti (from stomach)
Orientophorus brevichirus Srivastava (from intestines)
O. gangeticus Srivastava (from intestines)
O. ilisha Srivastava (from intestines)
O. clupii Srivastava (from intestines)

Cestoda:

Rhynchobothrius ilisha Southwell and Prashad (larval forms from muscles)
Ilisha parthenogenetica Southwell and Prashad (from mesentery and liver)
Gymnorhynchus gigas (Cuvier) (from mesentery, liver and coelom)
Synodesmobothrium filicolle Linton (from mesentery of the intestines)

Acanthocephala:

Acathosentis indica Tripathi

Copepoda:

Clavallisa ilishae Tripathi (from gill rakers)

3.3.6 Greatest size

The maximum length so far observed from Indian waters is 60.5 cm (Karamchandani, 1961). Such large specimens are more common in the catches off Saurashtra coast and the Narbada.

3.4 Nutrition and growth

3.4.1 Feeding (time, place, manner, season)

3.4.2 Food (type, volume)

Hora (1938, 1940) found that hilsa is a plankton feeder and that the closely-set sieve-like gill rakers on the branchial arches are adapted for straining microscopic organisms. Jones and Sujansinghani (1951) have inferred that it is essentially a plankton feeder and does not show any selectivity in feeding, as far as the different kinds of plankters are concerned. Both zoo- and phytoplankters are readily consumed. Chacko and Ganapati (1949) have recorded diatoms, protozoans, crustaceans, molluscs and tunicates as the main constituents of its food in the coastal waters of Godavari district in Andhra Pradesh. Pillay and Rao (1962) found that in the Godavari organic debris, diatoms and zooplankton (crustacea) formed the major constituents of the food of adult as well as young hilsa. It has been observed by a number of workers that during spawning migrations the intensity of feeding decreases or ceases altogether, though Pillay (1958) has reported that he did not find any evidence of cessation or appreciable decrease in the feeding activity during the spawning period. Pillay (1958) further observed that the stomachs of spent hilsa contain considerable quantities of mud and sand, showing that they feed at the bottom. The intensity of feeding during the post-spawning period appears to be very high. Pillay and Rao (1962) found that young and adult hilsa in the Godavari feed at the bottom as well.

3.4.3 Relative and absolute growth patterns and rates

One of the major handicaps in the study of hilsa populations is the lack of a suitable method for age and growth determination. A number of workers (Hora and Nair, 1940; Prashad, Hora and Nair, 1940; Chacko, Zobairi and Krishnamurthy, 1948; Chacko and Krishnamurthy, 1950; Jones and Menon, 1951; Raj, 1951; Pillay, 1958) have tried to interpret growth or spawning marks found on the scales, but the results have not been encouraging so far.

Chacko, Zobairi and Krishnamurthy (1948) found a correlation between the number of radii and the length of the fish. Raj (1951) confirmed that such a correlation holds good except in fully grown fish, but he expressed doubts regarding the usefulness of radii in estimating growth rate. Pillay (1958) has concluded that the number of

radii on the scales is not related to the age of the fish and is therefore of no use in determining either age or growth rate of the species. By the study of the spawning rings presumed to be formed due to the cessation of feeding during the spawning season, Chacko and Krishnamurthy (1950) inferred that 28 cm long male hilsa have spawned once and 38.2 cm long female, twice. On the basis of studies of the species from the Hooghly, Pillay (1958) expressed the view that the markings referred to by the above authors as spawning marks are formed too irregularly to be reliable for age and growth determination. The only method now available for the purpose, is analysis of length frequency.

Hora and Nair (1940) have studied the growth rate of young hilsa in the Pulta water works by the periodic examination of length frequencies. The growth rate observed by them is summarised below:

Age (months)	Length (mm)
1	40-50
2	80-89
3	100
4	130
5	160
6-12	increase at a monthly rate of 20 mm

Sujansinghani (1957) who studied the growth rate of young hilsa in the tidal stretch of the Hooghly for three seasons, recognised appreciable variation in the rate of growth between seasons. From his data, it would appear that the growth increment in the first month after spawning is 2.8 cm to 3.3 cm and in the subsequent months between 1.5 to 2.5 cm. On the basis of length frequency studies Sarkar (1957) has expressed the view that the rate of growth of hilsa in the Sunderbans area of West Bengal is 40 mm between December and January and 20 mm between February and March. From the analysis of length frequency data, Pillay (1958) has concluded that male hilsa in the Hooghly attain modal lengths of 24.7 cm, 34.3 cm and 39.3 cm and females 26.5 cm, 39.1 cm and 43.6 cm in 1.1/2, 2.1/2 and 3.1/2 years respectively. Annual growth rate of +2, +3, +4, +5 and +6 year age groups appear to be 6.0 cm, 4.0 cm, 3.0 cm, 2.0 cm and 2.0 cm respectively and the limiting length of the Godavari hilsa has been found to be 60.6 cm. (Pillay and Rao, 1962)

3.4.4 Relation of growth to feeding, to other activities, and to environmental factors

No direct relationship between feeding intensity and growth has yet been elucidated in the species, but it is reported that there is a definite lessening in the intensity of feeding of maturing hilsa migrating up-river for spawning. The period of intensive feeding would appear to be winter months, except during January and February when there is a migration of adult hilsa up-stream. As already mentioned, spent hilsa have been observed to feed very intensively.

3.5 Behaviour

3.5.1 Migration and local movements

A number of workers have made observations on the migrations of the species on the basis of studies of commercial catches. Day (1873) described the anadromous nature of hilsa in the Gangetic rivers and stated that the fish spends a part of its life in the sea, not far from the shallow coastal belt. Prashad (1919) expressed doubts as to whether the fish is really anadromous as it is found in the rivers almost throughout the year. Naidu (1939) has referred to the occurrence of hilsa in the Ganga as far up as Patna and Banaras, indicating a very long range in the migration of the fish from the sea. Raj (1937) on the basis of observations made in the south Indian rivers stated that the fish spends the first year of its life in the lower reaches of rivers and goes to the sea in the third year. Prashad, Hora and Nair (1940) have stated that the fish migrates into the sea during the first year of its life, where it moves along the foreshore and does not go far out into the sea. Hora (1940) pointed out that among the mature hilsa that swarm into the rivers during the flood season for spawning purposes, there are a number of young individuals also and these travel far up before they become sexually mature. From a study of the sex ratios of hilsa ascending Narbada near Broach for breeding, Karamchandani (1961) has indicated that the males ascend to the spawning grounds earlier than the females. According to Hora

and Nair (1940 a) the jatka (small sized hilsa) caught in East Pakistan rivers are five months old and are migrating up the estuaries for feeding. It has, however, been shown by Pillay (1958) that these fish are mature and migrate up-river for spawning during winter months.

The occurrence of two runs of hilsa in the main river systems, one during the southwest monsoon and the other during late winter, has been referred to in section 3.1. The late winter run is of a smaller magnitude and has been clearly recognised in the Hooghly, Narbada and the Chilka lake (Kulkarni, 1951; Jones and Sujansinghani, 1951; Jones 1957; Pillay, 1958). Day (1873) has also described such small runs in the Indus and the Irrawadi in March and April, the cause for which he attributed to the melting of snow in summer in the upper reaches, causing a minor flood.

Recent investigations have shown that probably the range of migration of hilsa is not as great as was originally believed, and that the fisheries of the Gangetic system of rivers bear on more than one stock. (Pillay, 1952; Pillay, Rao and Mathur, 1963) While the estuarine stocks migrate up the river for spawning and return to the river mouths and adjacent foreshore areas, the stocks in the fresh water regions of the Ganges (Ganga) do not seem to migrate to the sea. However, even among these fish an upstream migration has been observed during the breeding season.

Previous workers have held the view that there are two types of migrations of the hilsa in the Gangetic system of rivers; one for breeding and another for feeding (Howard, 1938; Hora, (1941). Pillay (1958) has stated that the hilsa ascend the rivers only for spawning and the spent fish as well as their progeny migrate down the river. Tagging experiments recently conducted (Pillay, Rao and Mathur, 1963) have served to prove this more conclusively.

The fish is known to be a fast swimmer (Southwell and Prashad, 1918 a) and tagging experiments have shown that a fish may cover as much as 70.8 km in one day (Pillay Raj (1917) has observed that the tendency to jump in the air is very prominent in the species and that the fishermen at the lower anicut (river Godavari) avail of this habit to trap them with spread out nets. Southwell and Prashad (1918) have stated that such behaviour has never been observed in Bengal waters.

3.5.2 Schooling

During migrations upstream the fish do congregate but they have never been observed to form very dense schools as observed in the case of many pelagic fishes. During winter months however they have been found to form very large schools at the entrance of the Hooghly estuary and at that time very large seine nets are used to surround such schools. Hilsa congregate in large numbers below dams or other obstructions to their up-river migrations. According to Southwell and Prashad (1918) hilsa that move near the bottom of rivers rise to the surface when they meet obstructions such as dams or anicuts. Kulkarni (1950) has observed that ripe hilsa are caught both from the surface and near the bottom in the Narbada river.

Figure 7. Marking of Hilsa ilisha with a nylon streamer tag.

4 POPULATION (STOCK)

4.1 Structure

4.1.1 Sex ratio

While Chacko and Ganapati (1949) recorded the ratio of males to females in the Godavari as 1:9, Pillay and Rao (1962) found the average ratio to be 1:1.53 differing significantly from the theoretical ratio of 1:1. The males predominated the catches at the beginning of the breeding season, while the females were more numerous at the close of the spawning season. In the case of Hooghly hilsa Jones and Menon (1951) reported that the ratio of males to females is generally constant, with a preponderance of males at the commencement of the breeding season and of females during the period of spawning. A critical study of the catches from the Hooghly during different months has, however shown that there is no significant deviation from the expected ratio of 1:1 in the monsoon run of the fish in the river and the predominance of males in the winter catches is attributable to selective fishing (Pillay, 1958). Studies of catches from the Ganga at Buxar (Bihar-India) have also shown that there is no deviation from the expected sex ratio of 1:1 (Jhingran, 1957). Karamchandani (1961) has observed that the ratio of males to females in the catches at the beginning of the spawning season (July) at Broach on Narbada was 3.5:1 and becomes 1:1 as the season progresses.

4.1.2 Age composition

The commercial catches of adult hilsa in the river systems of India are generally composed of age groups 1+ to 5+ years, the dominant age classes usually being the 2+ and 3+ year groups. The monsoon fisheries are contributed mainly by the larger sized fish, the smaller size groups forming the fishery during the winter months. This general pattern has been found to hold good in the Hooghly, the Padma, the Ganga and the Godavari where there are distinct monsoon and winter fisheries for the species.

The pattern of abundance and the age class composition of hilsa catches in the Hooghly and the Padma during 1950-1955 were analysed by Pillay (1957, a) who has demonstrated that the dominance of the 1+ year age group during the winter of 1952 contributed to increased landings in the monsoon fishing seasons of the subsequent years leading to unusually heavy catches in 1955 composed mainly of 4+ year old fish. Thus he has traced the abundance of hilsa in Bengal waters during the monsoon of 1955 to the exceptionally intensive and successful spawning during the monsoon of 1950.

In the Brahmaputra and the Barak, commercial catches in the monsoon months of 1956 have been found to consist mainly of 3 year old hilsa (Pillay and Ghosh, (1958).

4.1.3 Size composition

Occurrence of juveniles of 16 mm length and above in the settling tanks of the Pulta water works on the banks of the Hooghly at Barrackpore was taken as proof of the occurrence of the larvae and juveniles in the river itself throughout the year by Hora and Nair (1940). They obtained young hilsa of 20 mm to 99 mm length from the Hooghly at Nawabgange in October, November and February-March. They also recorded extensive fisheries of young hilsa of 175 mm to 275 mm length in the rivers of East Pakistan during the winter months. Pillay (1958) in referring to the above record, showed that the winter run of smaller sized hilsa is common to the Hooghly as well as the Padma, and that these fish were the 1.1/2 year age group with modal size of 253 mm which have attained maturity.

He recognised five size groups in the commercial catches from the river, viz. juveniles with a modal size of 62 mm.

Age (years)	Length (mm)
Immature	
Mature 1.1/2	
" 2.1/2	364
" 3.1/2	446

He found that the modal lengths of mature male and female hilsa of age groups 1.1/2, 2.1/2 and 3.1/2 differ significantly as shown in Table IX.

Table IX
Modal lengths of male and female hilsa

Modal lengths of males	Modal lengths of females	Age (years)
24.7	26.5	1.1/2
34.4	39.1	2.1/2
39.3	43.6	3.1/2

He further observed that larger sized hilsa were more predominant in the catches in the lower Sunderbans during the winter months than higher up the river.

Chacko and Ganapati (1949) observed that female hilsa attain larger size than the males in the Godavari. The females measured 356 mm to 600 mm, their weights ranging from 227 g to 2,500 g, while the male fish ranged from 300 mm to 432 mm in length and 114 g to 680 g in weight. Based on the study of length frequency of hilsa caught in the Godavari, Pillay and Rao (1962) surmised that hilsa of total lengths 41.5 cm, 45.5 cm, 48.5 cm, 50.5 cm, and 52.5 cm represent the +2, +3, +4, +5 and +6 year age groups. Difference in size between sexes was noticed also by Jhingran (1957) who analysed the hilsa catches at Buxar in the Ganga. He found the male fish ranged in length from 221 mm to 465 mm and the females from 325 mm to 485 mm Karamchandani (1961) found that in the Narbada larger sized fish (males 315 mm to 485 mm; females 415 mm to 555 mm) migrate higher in the fresh water zone of the river than the younger smaller fish (males 265 mm to 315 mm; females 295 mm to 415 mm) which are abundant in the tidal areas of the river and totally absent in fresh water areas. Jones and Sujansinghani (1951) in their study of the hilsa of Chilka lake found that they occur in the lake throughout the year, their length ranging from 84 mm (immature; December-January) to 520 mm.

4.2 Size and density

The size and density of any of the hilsa stocks have not yet been determined. Violent fluctuations in the abundance of the fish in different river systems have been observed and it is believed that there is five year periodicity in the abundance of the fish (Hora and Nair, 1940; Hora, 1940). The inference of Pillay (1957) that the great abundance during the year 1955 in the Hooghly and Padma rivers was due to the unusually successful spawning in the year 1950 has been referred to in Section 4.1.2. Hora and Nair (1940) have indicated that the variations in the monsoon are probably responsible for the usual fluctuations in the annual crop of the species.

4.3 Natality and recruitment

Even though young hilsa are caught in bag nets in some areas as in the river Hooghly, the recruitment to the fishable stocks in most areas takes place when the fish are one to one and a half years old and have attained sexual maturity. The recruitment rates appear to fluctuate very greatly from year to year in the species and this fact appears to be largely responsible for the fluctuations in the fisheries.

4.4 Mortality, morbidity

No definite information on mortality rates is at present available even though data are being collected for the estimation of these in selected areas in India. Morbidity even on a small scale, has not so far been observed.

4.5 Dynamics of population

There is a general belief that the hilsa fisheries of the Indian region are fast becoming depleted. This belief is largely based on the inadequacy of supplies in markets and increase in consumer prices. As already mentioned, considerable fluctuations have been noticed in the abundance of the fish. Detailed information on the dynamics of the populations is not available. It is reported that in West Pakistan the catches are definitely dwindling, but in East Pakistan there is no marked difference in the catches (IPFC, 1961).

4.6 Relation of population to community and ecosystem, biological production, etc.

No information is available on this aspect except that in the estuarine and coastal areas of West Bengal, it has often been noticed that a great abundance of plankton during winter months is associated with the occurrence of dense schools of hilsa in the area.

5 EXPLOITATION

5.1 Fishing equipment

5.1.1 Fishing gear (See Table X)

A wide variety of nets are used to capture hilsa, many of them specially devised for the species. Even the same net varies considerably in size, mesh, etc. from place to place. Besides the nets specially meant for catching hilsa, the fish are caught in many other nets along with other fishes. In Table X therefore, only the more important hilsa nets are described.

The fisherman's choice of nets for operation in different areas and different seasons is dependent on the velocity of the current, the nature of the catch and to a large extent on his financial situation. Hornell (1924 and 1950), Naidu (1939), Ahmed (1954) and Jones (1959 and 1959 a) have described hilsa fishing gear and its operation in the Indian region, which is summarised in Table X. In Iran most of the fishing is by means of large reed traps (Bertram, 1944).

5.1.2 Fishing boats

The type and number of boats used for the operation of hilsa fishing gear have been indicated in section 5.1.1 above. In all countries hilsa fishing is done from small sailing boats except on the Saurashtra coast (India) where mechanised small boats have now been introduced for the operation of gill nets which catch hilsa as well as other fishes. According to Bertram (1944) hilsa is caught in Iran along with other fishes by the "bellum", an elongated plank-built craft about 9.2 m long and shaped like a dug-out canoe, or the "mihayle" a kind of river dhow about 10.7 m long. In West Pakistan two types of boats known as "donda beri" and "bathela" operated by 14 and 2 men respectively, are used for hilsa fishing and there are about 575 such boats in the area. In India on the Saurashtra coast dugout boats known as "hodis" which are 6.7 m to 7.9 m long and 0.9 m to 1.2 m wide (operated by 3 or 4 men) and large clinker built partly decked boats of 10 to 20 ton capacity (with a crew of 5 to 8 men) are in use. Hilsa fishing in the Narbada is done from flat bottomed boats of about a ton capacity varying from 6.1 m to 9.1 m in over-all length, and operated by 3 or 4 men. In the river Godavari, open plank-built undecked boats known as "nava" of about 7.3 m length and 1.2 m width (about one ton capacity) are used for operating hilsa nets. In Chilka lake fishing is done from plank-built flat bottomed boats known as "naha" though for small-scale fishing operations close to the shore dug-outs are also used. In the Mahanadi estuary plank-built flat-bottomed boats known as "dongya" which are about 11 m long and about 1.8 m to 2 m wide are used along with smaller boats known as "huli" which are about 6 m to 9 m long and 45 cm to 55 cm wide. In West Bengal and Assam different types of "dinghies" and plank-built "chandi nauka" are used mainly for hilsa fishing even though other types of fishing boats are also often used for the purpose.

The "dinghi" or "jale dinghi" or "pansi nauka" as they are called in Assam, may be of different dimensions varying from 3 m to 9.1 m in length and 0.9 m to 1.8 m in width. They are plank-built and shallow with pointed and elongated bow and stern and are mainly used for the operation of clap nets and dip nets. The smaller boats are used for operating only one clap net, whereas from larger boats two nets may be operated. Pillay and Ghosh (1958) have estimated that there are about 2,200 such boats operating in the Brahmaputra and 800 in the Barak in Assam. The "chandi nauka" is bigger and is generally used in the estuarine areas for fishing with drift gill nets. It is plank-built, partly decked, often up to 18.3 m in length and 3 m wide. For the operation of the boat a large crew, seldom less than six, is required. It has three to seven pairs of oars and a big steering paddle tied to a hole on the port side. The mast is located far in advance and usually carries a square sail and at times, if the wind is favourable, a top sail also. The fishing boats in East Pakistan are very similar to those found in West Bengal (India) and it is estimated that there are 48,040 boats in use in the area (IPFC, 1961).

Table X
Hilsa fishing gear

Type of gear English name	Vernacular name	Area of operation	Dimensions Length (m)	Breadth or depth (m)	Size of mesh (cm)	Material	Number of men required	Number and type of boats required	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Clap net	Kharki jal	Hooghly (West Bengal)	Length of bamboo frame of lip: 8	2	5-10	7-10 ply 22 counts cotton, tanned with gab	1-2	1 (dinghi)	Purse-shaped rectangular net with bamboo framed lips. Mouth kept open by vertical bamboo attached to lower lip and passing through the upper. Net kept suspended from prows of the boat which drifts downstream with the current. When fish enters the net its mouth is closed by pulling up the bamboo pole. Primarily for hilsa
	Sharki jal	Padma (East Pakistan)	3.7-9	1.8-9	4-9				
	Kamijal or Ilish jal or Sharki jal	Brahmaputra (Assam)	Length of bamboo frame: 4.5-6	Greatest width of bag: 4 m width of mouth 2-4 m	12-15	7-8 ply 20 counts cotton or 9-10 ply 40 counts cotton	2	1	Similar to Karki jal above, but conical in shape. Operated at the surface with about 1/3 of mouth opening above water level
	Sangla jal or Shangla jal	Hooghly (West Bengal)		3-4	8-11	7-12 ply 22 count tanned with gab	1-2 men for one net; 3 men for two nets	1 (dinghi)	Improved modification of Karki jal. Circular bag with thinner bamboo for lips. Can be set at any desired depth. Mouth kept open by weight tied to lower lip, and closed by pulling rope attached to middle of lower lip and passing through the upper. Sometimes 2 nets operated

Table X (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Khosh jal Hilsa jal Lawa jal	East Pakistan	4.9	1.8-6	2.5-7.5				simultaneously from a single boat. Primarily for hilsa
	Sangla jal	Brahmaputra (Assam)	Bamboo frame 6-7.5	3-4	12-15	9-10 ply 40 count cotton		1 Pansi nauka when 2 nets are operated. Kosa nauka when only 1 net is operated	Same as above
	Chairon jal Funga jal	Barak (Assam)							Very similar to the Shangla jal
	Sungail jal Sungla jal Hilsauri	Ganga (Bihar)	9	4.5	10		2-3 men	1	Very similar to the Shangla jal of West Bengal
	Kamail jal	Ganga (Uttar Pradesh)							As above
	Biri jal	E. Pakistan	9	14	6.3				As above - used for catching small hilsa
	Honga jal	E. Pakistan	7	3	5-10				
Gill nets	Chhandi jal	Hooghly (W. Bengal)	Each piece 10-12 m (25-75 pieces in a net)	2.5-8	6-10	Cotton or hemp, used tanned in turbid waters and untanned in clean waters	3-4 men	1 Chhandi nauka	A drift net. The net as well as the boat drifts down with the current gilling ascending hilsa. Floats of bamboo keep the headline afloat. Operated generally in the evening - primarily for hilsa
	Chhandi jalo	Dhamra and Mahanadi estuaries (Orissa)	Overall length up to 370 m	1.2	5-10				Very similar to Chhandi jal of West Bengal

Table X (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Ilish jal or Dora jal	W. Bengal E. Pakistan Orissa	Overall length 60-300 m	5-8	5-8			1	Same as above
	Konta jal		Each piece 18 m (4 or more pieces in a net)	8	5-8	Cotton 6 ply no. 10 thread		1 (dinghi)	Fixed gill net. The net is stretched across the river and fixed with bamboo poles and anchors. A number of buoys (empty tins) keep the head rope afloat. Fish are gilled. Net inspected every 2-3 hours
	Ilishi jalo or Ilishi phandi	Rivers and estuaries in Balasore (Orissa)	Each piece 15 m (2-3 pieces in a net)	5		6 ply 10 counts cotton, or 8 ply 20 counts cotton or hemp	2	1	Fixed gill net. Bamboo floats are used for the head rope. Fish are gilled. Primarily for hilsa
	Bhiro jalo or Bheed jalo	Balasore coast (Orissa)	Overall length: 200-600 m (each piece 18 m)	5.5-9	10	6 ply 10 counts cotton	6-10	2	Modification of above. Shoal of hilsa is encircled and driven into the net to be gilled
	Tisto jalo	Foreshore areas of Balasore (Orissa)	Each piece 18-27 m (3-5 pieces in a net)	1.4	10	6 ply 20 counts cotton or hemp		No boat	Fixed gill net tied during low tide to stakes, 9 m apart, about 400 m from shore. During high tide water rises above the net and fish are gilled
	Basani jalo	Balasore coast (Orissa)	Each piece 38 m	4.5	4-7	8 ply 16 counts cotton or hemp	2-4	1	The net has wooden floats and iron sinkers and is operated from a boat, encircling a shoal of fish. Hilsa and other fish are gilled

Table X (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Dondi jal or Dandi jal		2.5		2.5		2	No boat	Held stretched with bamboo poles. Two men hold the net and swim with the current. Ascending fish are gilled. Hilsa frequently caught
	Rangoon vala	Godavari and Krishna (Andhra Pradesh)	Each piece 5-5.5 30 m or more (usually six pieces in a net		10-13	Cotton 10 counts 6 ply	2-3	1	One end of the head line which has a series of floats is tied to the boat and the other end paid out, the boat drifting down with the current. The ascending fish are gilled. There is no footrope or sinkers for this net. Main hilsa catching gear in these rivers
	UllaValai or Ullam valai or Kanni valai	Cauvery (Madras)							Same as above
	Budichi jal	Narbada (Maharashtra)	Each piece 2.1-22 about 22 m (10 or 12 pieces joined to form one net)		12.5		3-4	Flat-bottomed boats (6 to 9.3 m)	Provided with clay sinkers and floats (gourds). Operated near the bottom. One end of the net is tied to the boat which drifts with the current. Fish swimming upstream are enmeshed in the net. Operated for large-scale fishing for hilsa

Table X (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Palwa jal	Kodinar (Sea) (Gujerat)	Each piece 28 m (30-50 pieces in a unit)	2.7-3.7	5-6.3	Cotton tanned with the bark of Terminalia tomentosa (Sajjad chal)			Driftnet: Head rope with a number of wooden floats and foot rope without sinkers. Operated at the surface, the net drifts with the current.- Hilsa net
	Valli jal	Varaval coast (Sea) (Gujerat)	Each piece 31 m (30-40 pieces in a unit)	2	10	12 ply 20 counts cotton			Head rope with wooden floats, foot rope without sinkers, the two ends anchored and buoyed. Hilsa and other fishes caught
	Amyaw paik	River and estuaries of Burma	15-90	2.7-3.7	10-12.5	Cotton			Head rope with floats, but no ground rope or sinkers. The net drifts with the current and the fish are gilled. - Hilsa caught as well as other fish
	Nga-thalouk paik	Mergui Archipelago Burma	Total length 550 m (3 sets in a unit, each set with 20 pieces, 9 m long)	11	10-15		12	3 (1 mother boat (6 ton) + 2 net boats (2 ton)	When a shoal is sighted it is encircled by the net paid out simultaneously from the two boats. The net is handed into the two boats which traverse the circle in the reverse direction. Fish are gilled
Seine nets	Kochal jal	Sunderbans (W. Bengal) Also in E. Pakistan	Each piece 12 m. 22-24 pieces in a net	30	8-10	10 ply 20 or 22 counts cotton	25-30	5-6	On sighting a shoal of hilsa the net is paid out from two boats encircling the shoal. Specially meant for hilsa

Table X (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Gai ber jal or Tanaber jal	Estuaries and rivers in W. Bengal and E. Pakistan	300 m or more	3-9	1-5	Cotton or hemp varies from 5 ply 5 or 10 counts cotton to 20 ply of 10 counts		2	Operated as encircling net, either in the middle of the river, or from the shore enclosing a large area of water. Primarily for hilsa
	Kona jal	Estuaries of W. Bengal and E. Pakistan	30-300	-9	5 cm (mesh of bags about 2.5 cm)	Cotton		2	Boat seine with a series of bags, each with a funnel-shaped pouch inside of 9-12 m to prevent the escape of trapped fish. The mouths of bags are kept distended by two diagonally placed bamboo poles. The net is used as a dragnet from the shore, or fixed to stakes in the river where there is strong current
	Pedda ayilu or Peddavala	Godavari (Andhra)	Each piece 30 m (6-10 pieces)	18	2-2.5		30-35	2	The net is paid out from 2 boats simultaneously in the form of a semicircle ending on the shore. Men on the shore drag the net close. Large catches of hilsa along with other fish
Fixed bag net	Behunti jal or Behundi jal or Bainti jal or Bin jal	Estuaries in West Bengal	25 m with wing fully stretched (Each wing 9 m and mouth 6 m)	Depth of bag 20 m	Near the mouth 4 cm	Cotton yarn. Cod end sometimes of hessian or thick canvas cloth			Operated in estuaries where there is strong tidal current. Wide mouth, comparatively short wings and long cod end. Provided with a flap to prevent fish swimming out. The net

Table X (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
									is fixed with two heavy anchors on two wooden spikes driven in the bed of the estuary. The mouth is kept open with two bamboo poles. Large quantities of juvenile hilsa are caught
	Suti jal	Rivers and estuaries of E. Pakistan	5-6	Ht. of wing 1-1.5					A modification of the Behundi jal. A stake passing through the centre of the mouth anchors the bag and also keeps the mouth open
Lift nets (dip nets)	Gara besal jal	W. Bengal	11-14	8-11 m across	4				A fixed lever net, roughly triangular, with a V-shaped frame of bamboo. Fixed in the river bed close to the bank. Catch removed periodically.
	Nauka besal jal	W. Bengal	9-11	6			3	1	Similar to the above, but smaller in size and worked from a boat
	Bhahali jal	Assam (Brahmaputra) Dubri to Gauhati	Length of the longest side: 5 m, shortest 1.2 m and the other two: 3 m each		6-9	12 ply no. 40 counts cotton	2	1	A large bag net with V shaped frame and operated from a boat drifting with the current

Table X (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Batchari jal or Othar jal	Sunderbans (W. Bengal)	Diameter 15-23 m			Cotton	5	1 (Bachari nauka)	Large-sized heavy cast net with puckerings and sinkers. The net is paid out from a boat as it drifts with the current. Generally a number of boats form a circle round a shoal and operate the nets simultaneously
Barrier nets	Charpata jal or Char gherra jal	Foreshore areas (W. Bengal)	Length of each piece 7 to several m. (number of pieces varies considerably)	3-4	Upper portion 5 cm lower portion 1.3 cm	Cotton (10-16 ply of no. 10 count or hemp or jute			The ground rope of the net is tied to a series of poles fixed in the mud just above the low-water line, sometimes extending over 1,600 m. At the peak of high tide fishermen in boats raise and fix the head rope to the poles above the water line. After the water recedes the stranded fish are collected. - Hilsa forms an important catch
	Mal jalo	Balasore Coast	Length of main constituent parts 1) Cunajalo: 140 m 2) Nanlyajalo: 120 m 3) Santiyajalo: 146 m	Main net 1-4.6 m Chouhandra jalo 1.2-1.5 m	1) 1.0-7 cm 2) 5 cm 3) 1.2 cm 4) 1.3 cm	1) 8-10 ply 16 or 20 counts cotton or hemp 2) 6-8 ply 10 counts yarn 3) 4-6 ply 10 counts yarn 4) 8 ply 10 counts yarn			A V-shaped series, each arm of the V composed of three parts: 1) Cunajalo (2) Nanlya jalo and (3) Santiya jalo; and a U-shaped net, the Chouhandra jalo, into which the apex of the V fits; together forms the Malo jalo. Operated in the tidal zone, the net being completely submerged during high tides. Fish are gilled as well as trapped when the water recedes

Table X (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Kappu valai	Cauvery (Madras)	Height including the handle 3-3.5 m	Width 1.2-1.5	2.5-6.0	6 ply 20 counts cotton or 8 ply 40 counts	1		Large oval ring net fixed to a V shaped frame. Used as a drifting push net, the fisherman floating down the rivers on a log of wood with the net held in front. The ascending fish are gilled. - Used especially for hilsa during high floods
	Gamda jal	Narbada (Maharastra)					1		Similar to the above, with a cross on the ring and fork. Operated during high tide, catching ascending hilsa. As soon as a fish strikes the net it is lifted and the fish removed
	Sandh jal or Sumbokee	Indus W. Pakistan	Handle 6.5 m long	Side 2 m	5		1		A long-handled net with a triangular frame. - Operation same as above
Cast nets	Khepajalo	Mahanadi (Orissa)							Operation from tiny platform built on tall poles fixed in the river bed. Wide-meshed folding and puckering type of cast net. - Mainly for hilsa
	Veechu valai	Cauvery	Circumference 13-15 m	3	6 x 8	20 count 10 ply cotton (untanned)	1		Number of such nets operated together, the fishermen standing in shallow water. In deeper waters the fishermen stand on a floating raft made of 5-6 logs of wood

Table X (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Trapping	Matlee (Palla pot)	Indus (W. Pakistan)	Length of shaft 6 m bag much deeper					1	The fisherman, floats down, seated on the bow of a small punt or supported by gourds or on the mouth of an earthen pot, the net held in a vertical position in front
	Bandal	Ganga (Uttar Pradesh)							Operated where the river takes a turn or bifurcates. Bamboo fencing in the form of a V, one arm longer and curved towards the shore, is set up. Ascending hilsa congregate in the angle of the V and are removed with a scoop net or lift net (Ghauch) operated from a platform or from a boat
	1) Chondi jalo 2) Chawk jalo	Mahanadi and Dhamra (Orissa)		6-9	1) 7.5-9 cm 2) 5 cm	hemp	Several (200-300)	Several Donga and Huli	The operation is known as "fish drive". Two rows of stakes with nets are fixed across the rivers. Fish are driven towards this barrier and a wall of several layers of net dragged towards the barrier net. The fish in the enclosed space are collected using boats (dongyas) and dip nets. - Large shoals of hilsa are captured this way

Table X (contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Drag net	Maha jal	Ganga	Overall length 450-650 m (each piece 14 m)	4.5-6	2.5-6			30-40	Catches: Hilsa as well as other fishes
	Jangla jal	W. Bengal	12.2-15.2 m Several pieces joined over-all length: 915 m	7.5-9.1	3.8	Cotton 10.5 count	8-10	2	The head rope with floats and ground rope with weights. Bottom edge of net is puckered having pockets. Each boat carries half of the net and pays it out

Figure 8. The Clap net, Sangla jal operated in West Bengal and East Pakistan waters for catching hilsa.

Figure 9. Cast net operated from tiny platforms built on poles in Mahanadi River, for catching hilsa.

Figure 10. Fishing for hilsa with seine net in River Cauvery.

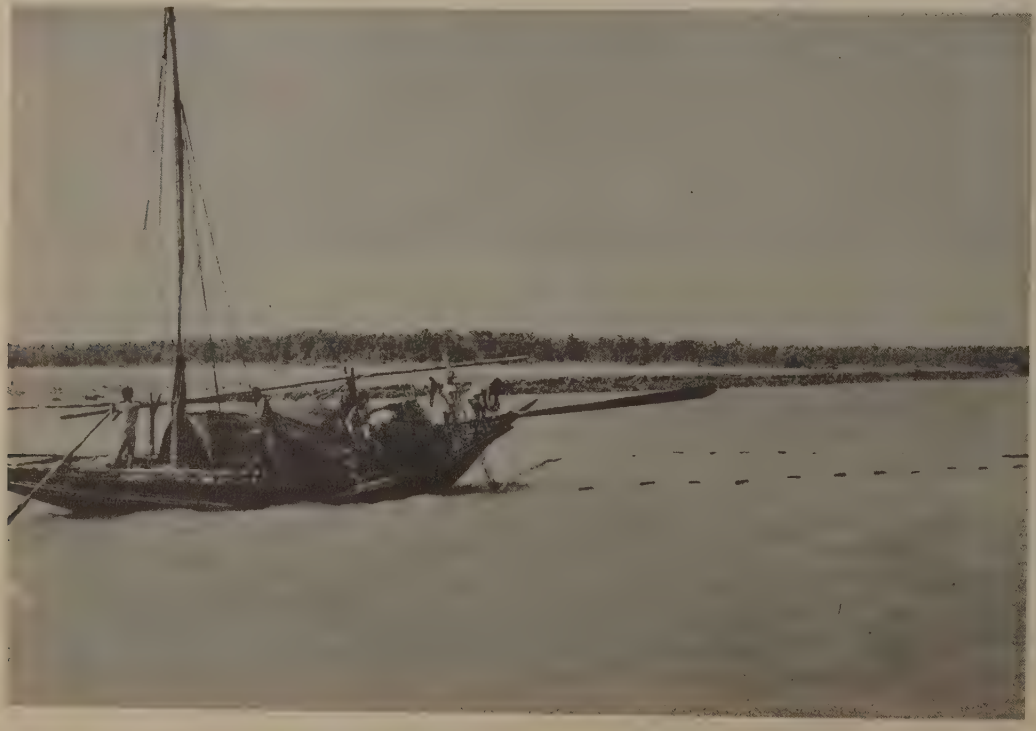

Figure 11. The Kona jal used for hilsa fishing West Bengal and East Pakistan.

Figure 12. A Janglo jal in operation in the Sunderbans (Gangetic delta), West Bengal.

Figure 13. A Kochal jal being hualed up in Sunderbans (Gangetic delta), West Bengal.

5.2 Fishing areas

5.2.1 General geographic distribution

Table XI

General geographic distribution[1/]

Iraq	Iran	W. Pakistan	India		E. Pakistan	Burma
			West Coast	East Coast		
Shatt al-Arab	Shatt al-Arab	Indus	Narbada	Cauvery	Meghna	Irrawady
Euphrates	(Abadan Island)		Saurashtra Coast	Godavari	Padma	Mergui Coast
Tigris				Krishna	Jamuna	
Lake Hammar				Mahanadi	Deltaic system of the Ganga	
				Chilka Lake		
				Hooghly	Brahmaputra	
				Digha & Chandipore Coasts		
				Ganga & its tributaries		
				Padma		
				Brahmaputra		
				Barak		

1/ The names listed are of rivers unless otherwise indicated (See Map Fig. 2)

5.2.2 Geographical ranges (latitudes, distances from coast, etc.)

Latitudes	32°N - 43°E
(approximate)	8°N - 107°E

See section 2.3

5.2.3 Depth ranges

In the rivers hilsa fishing is done in both deep and shallow waters ranging in depth from only a few cms, as in certain areas of the river Cauvery to as much as 15 fathoms in the lower reaches of the Gangetic delta. In the sea the fishing is mostly carried out in the shallow foreshore areas, but on the Saurasthra coast gill net fishing is done in depths up to about 20 fathoms.

5.3 Fishing seasons

5.3.1 General pattern of fishing season

Fishing for hilsa takes place mainly during the monsoon season when adult fish migrate up the rivers for spawning and is centred in the estuaries and rivers. A less important fishery takes place during the latter part of winter when there is a minor run of mature fish up river for spawning. Fishing also takes place during the winter season for young fish from estuaries and river mouths.

5.3.2 Duration of fishing season

The duration of fishing season varies in different areas. Fishing in the rivers generally starts after the commencement of the southwest monsoons when the rivers are flooded, and lasts till two to three months after the monsoons. The winter fishing season is limited, and generally starts by about December in the lower reaches, and January to February in the upper reaches of the Hooghly. On the Digha and Chandipore coasts as well as Saurashtra coast, the fishing is done throughout the winter months. In Chilka lake and river Ganga, fishing is done throughout the year, though the peak periods are during the monsoons and winter.

5.3.3 Dates of beginning, peak and end of season

The available information on the beginning and end of fishing seasons and peak periods is tabulated in Table XII.

5.3.4 Variation in time or duration of fishing season

As the fishing for hilsa is largely dependent on its migratory movements the time and duration of the fishing season also varies with the time and duration of the migrations. The fishing season generally lasts as long as the catches are satisfactory. Mojumdar (1939 a) and Hora and Nair (1940) have observed that better catches are obtained during the spring tides. Kulkarni (1950) has also inferred that there is a similar lunar periodicity in the fishery in the river Narbada and that the best catches are obtained during the high water period on spring tide days.

5.3.5 Factors affecting fishing season

Variability of the monsoons causes considerable fluctuations in the catches of hilsa. In the lower reaches of the Gangetic delta including River Hooghly and foreshore areas, fishing is generally conducted during the winter months when the winds are not strong and the waters are calm. Rough weather conditions greatly affect the fishing season in these areas. In the foreshore areas adjacent to the Gangetic delta large seine nets are used to capture shoals of hilsa when the water is clear. High turbidity of water has been found to be a limiting factor for such fishing, as the shoals cannot then be easily detected.

5.4 Fishing operations and results

5.4.1 Effort and intensity

An accurate estimate of the hilsa fishing units operating in all countries is not available even though rough estimates have been made for certain areas. Generally the fishermen, who own hilsa fishing gear, fish for hilsa during the

Table XII
Beginning, peak and end of fishing seasons

Area	Main Season	Subsidiary Season	Peak Periods
Burma			
Irrawady	Southwest monsoon upto October	--	July to September
E. Pakistan			
Gangetic Delta	Throughout the year	--	May to October
India			
Brahmaputra & Barak	April to September	--	July to September
Hooghly	July to December	January-February to March	October-November and February
Padma	--	Throughout the year	July-September and December
Ganges (Ganga)	--	Throughout the year	April, June and October to November
Mahanadi	Southwest monsoon	Winter	--
Chilka Lake	--	Throughout the year	Commencement of the monsoons and close of winter
Godavari	July to November-December	January to March	--
Krishna	July to November	--	--
Cauvery	July to September	--	--
Narbada	July to September	March to May	--
Saurashtra Coast	September to November	April to May	--
W. Pakistan			
Indus	--	February to October	May to July
Iraq			
Euphrates) Tigris)	March to August	--	April

season and devote the rest of the year to other types of fishing. The number of fishermen operating in the Indus is estimated to be 5, 000 to 7, 000 and in East Pakistan about 185, 000. In West Pakistan 3, 251 nets and 575 boats are employed for hilsa fishing as against 97, 935 nets and 48, 046 boats in East Pakistan. The hilsa fishermen migrate from place to place depending on the abundance of fish. While a "Sangla jal" may catch only a single fish in each haul, the catch per haul of a large "Kochal jal" in the Gangetic delta may be as much as one metric ton. Depending on the abundance of fish, the catch per unit effort may vary considerably for each type of fishing unit from month to month and year to year.

5.4.2 Selectivity

As mentioned in Section 5.1, several types of drift gill nets and seine nets are operated for the capture of hilsa and they are highly selective, the size of the fish caught being dependent on the size of the mesh. The clap nets and dip nets are also selective to some extent and are designed to catch adult hilsa. Bag nets operated in the rivers of East Pakistan and West Bengal and the "Patua jal" of Chilka lake capture young hilsa along with miscellaneous fishes. Detailed studies on the selectivity of hilsa nets have not yet been made.

5.4.3 Catches

The highly dispersed nature of the fishing areas, the diversity of fishing gear used and the underdeveloped status of the fishing industry, are very serious handicaps to the collection of reliable statistics of fish catches. However, in selected areas in India, sampling surveys have been initiated for the estimation of total catch and catch per unit effort. Ad-hoc estimates of production have been made in Pakistan also. As mentioned in Section 5.5, considerable fluctuations have been observed in the catches from different areas and so the estimation of average catches is difficult. Van den Eelaart (1954) has estimated the production of hilsa in Iraq to be about 5 percent of the total landings of freshwater fish which is roughly 8, 000 metric tons to 10, 000 metric tons per annum.

According to Bertram (1944) the catches of the species in Abadan (Iran) from February to November in 1943 amounted to about 401.42 metric tons and from January to June about 336.67 metric tons. The catches from West and East Pakistan have been estimated to be as follows:

West Pakistan 907 metric tons to 2, 722 metric tons.
East Pakistan 13, 608 metric tons to 18, 144 metric tons.

In India the total catches of hilsa during a year of successful fishery has been estimated to average 16, 000 metric tons. The total catch figures available from selected areas where sampling surveys have been undertaken are given in Table XIII.

5.5 Fisheries management and regulations

No proper management or regulatory measures for hilsa fisheries are followed in any of the countries now. Free fishing is permitted in all areas except in such rivers as the Brahmaputra and Indus, where fishing rights are auctioned out.

The marked fluctuations in the fisheries of hilsa and the alleged depletion of the fisheries have already been referred to above. The fisheries in South Indian rivers have undoubtedly been adversely affected by the construction of anicuts and dams. The fish that gather below these obstructions are caught indiscriminately in very large numbers by fishermen. With a view to controlling this, the States concerned have enacted legislation to prevent the capture of hilsa within one mile (1.6 km) limit of such obstructions. Even though there is no law in the region at present to ensure the provision of fish facilities in dams or other obstructions built across rivers, the need for such facilities has been recognised. However, a suitable fishway for hilsa has yet to be constructed. It is reported that an experimental fishway designed by Sir Francis Day was constructed in the lower anicut at Coleroon in the Cauvery. His object was to employ under-sluices and vents in place of the usual kind of fish pass, and so to convert the anicut or part of it into a lock through which fish could easily pass. This fishway, did not work successfully.

Figure 14. A good haul of hilsa being lifted aboard.

Table XIII

Total catches from selected areas

	1958	1959	1960	1961
	Metric tons			
Hooghly	498.2	92.0	232.9	388.1
Padma	868.0	388.7	638.1	1166.7
Godavari	10.1	23.4	612.7	-
Ganga	121.1	121.4	200.1	

In 1916, a fish pass was constructed in the weir across the Mahanadi at Cuttack but just as at Coleroon, this was also found to be ineffective. On the river Indus a fish ladder has been provided in the Ghulam Mohamed Barrage, but due to various defects, this has also proved to be a failure. Talbot (1959) who studied the fishway has recommended a new fishway for installation at each bank of the river immediately behind the barrage to replace the present ineffective one. The width of the proposed fishway is 6 m and each pool is 4 m long. Each weir is 22.9 cm higher than the next lower one and the water in each pool is 30.5 cm higher than the weir at the lower end of the pool. Just inside the first entrance is a large collection pool where fish can accumulate before beginning the climb. Water flow through the entrance gate will be at 1.8 m per second with provision for adjusting it between 0.9 m to 3 m per second. Necessary provision is also made for the introduction of attraction water in the collection pool, as well as in the lower pools. He has also discussed the possibility of installing a fish lock or fish lift to pass hilsa up the Barrage.

The establishment of hatcheries for the artificial propagation of hilsa for stocking the rivers, to counteract the effect of dams across rivers, was advocated about 40 to 50 years ago (Raj, 1917) and a hatchery was established near the lower anicut on the River Godavari at Bobbarlanka in the then Madras Presidency (now in the Andhra State) in India. The results were far from encouraging and it was soon realised that it will neither be economical nor feasible to have sufficiently large hatcheries to compensate for the adverse effect of dams. Hora (1938) suggested that the brood and young fish should be protected instead of constructing hatcheries of fish passes. Devanesen (1942) has also suggested that the brood fish should be protected below the anicuts of rivers by legislative measures.

The large-scale capture of small-sized hilsa known as jatka in East Pakistan and hilsa khoira in West Bengal as well as fry and larvae has been considered highly destructive by Hora and Nair (1940) and Jones and Menon (1951), as such fish do not get an opportunity to breed even once. Legislation to prevent the capture of such immature fish was advocated. Hora (1954) has referred to the socio-religious injunction that was observed in West Bengal (India) in not eating hilsa from Bijoya Dasami (September-October) to Shri Panchami (January-February). This discouraged fishing for spent and immature hilsa during the winter season, which he thought had a highly conservational value for the fishery. This practice is no more followed and hilsa fishing on a large scale is now carried on in winter also.

Jones and Sujansinghani (1951) have advocated the restriction of fishing in the Chilka lake from the mouth of the Makra to the mouth of the Daya in a narrow belt of 3.2 km to 4.8 km for the protection of brood fish that ascend the rivers for spawning.

As mentioned in Section 2.3, there is a general belief that the rapid silting of rivers and lakes, is the major cause of reduction in the abundance of hilsa, and dredging operations have been recommended to improve the fisheries.

For the formulation of appropriate measures for the management of hilsa fisheries detailed information on the dynamics of the populations is required and to make this available a co-ordinated programme of research in the countries of India, Pakistan and Burma where the major hilsa fisheries are located, has been recommended by the Indo-Pacific Fisheries Council.

5.6 Fish farming, transplanting and other intervention

Attempts to artificially propagate hilsa for stocking rivers have been referred to in Section 3.1 and 5.5. That the hilsa thrives well in stagnant or semi-stagnant waters has been shown by their occurrence and rate of growth in the settling tanks of the Pulta water works near Calcutta (Hora, 1940) and the freshwater tanks connected with irrigation canals of the south Indian rivers Godavari, Krishna and Cauvery. Collection of fry and fingerlings as well as rearing in cement cisterns have been done successfully by Pillay (1958) for experimental

purposes. Large-scale culture of hilsa in ponds has been advocated by Mojumdar (1939 a) and Hora (1940) but earnest attempts have not so far been made in this direction.

The only known instance of an attempt to transplant hilsa was that of Wilson (Nicholson, 1915) who planted eyed ova of this fish from the hatchery at the Lower Anicut in the Cauvery in the Ponnani river in Malabar (India-West Coast), but there is no evidence of the fish having become established there.

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Horacio Rosa, Jr.
Biology Branch, Fisheries Division
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FB/S22	Etude synoptique sur la biologie du huchon *Hucho hucho* (Linné) 1758 (Edition provisoire)	Avril 1962
FB/S24	Synopsis of Biological Data on Grayling *Thymallus thymallus* (Linnaeus) 1758 (Provisional draft)	May 1962
FB/S25	Synopsis of Biological Data on Hilsa *Hilsa ilisha* (Hamilton) 1822	January 1963